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COST EFFECTIVE PV SOLAR ENERGY CONCENTRATING SYSTEM BASED ON MIRROR REFLECTION

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ABSTRACT

The objective of this paper is improving the solar energy by using mirror reflection concentrating on to the solar panel. The improvement of the output power using flat plane mirror reflector is even higher than that of sun tracking and secondly these reflectors are very cheap and are easily available in the market. The average power output during mid day as increased substantially using mirror reflectors, the solar panels equipped with such mirrors can also be utilized for loads/equipments requiring higher power inputs during that period of the day. And also side by side second application are water heater will be included. The high cost of PV modules makes the use of concentrator more desirable. Optical concentration offers other advantages including semiconductor solar cell increased efficiency. At present different types of PV concentrating solar energy system are developed. The price of the existing PV concentrating systems is high. To design the cost-effective concentrating PV systems it is necessary to realize the multi-parameter cost optimization of these systems. To concentrate solar energy we are using light reflection on to the solar cell by using mirrors. We are using PIC16F877A for measuring generated solar panel voltage and developed a graph in MATLAB software comparing to conventional concentrating system. And the output which obtained from mirror reflection system is more and reliable compare to conventional system.

KEYWORD: Concentrating photovoltaic (PV)system, Mirror reflection.

Introduction

The paper aims at developing more power using mirrors to harvest more of the incident solar irradiance and direct sunlight to qualified PV modules increases the electricity produced from a given area of PV panels. The system consists of 8.9V (5W) solar panel. The current flows from solar panel to battery. We are using mirror arrangement at both sides of solar panel for increasing its power efficiency.

Concept solar panel with mirror

Solar panels are a great way to make some green electricity for your home or workplace but there kind of expensive and sometimes the wattage produced can be a bit disappointing. If you use a sun tracking system to keep your solar panels facing the sun you can considerably improve the watt yield but these are not cheap. And on small system they can add considerably to the cost.

Here's a really cost effective and simple way to get 25% more power from any ordinary solar panel. And on small system they can add considerably to the cost. Here's a really cost effective and simple way to get 25% more power from any ordinary solar panel.

As shown in Figure 1.,The mechanical setup consist of two mirrors which are used as a concentrating mirror which reflects the sunlight onto the solar panel. Solar panel is vertically mounted between two mirrors. Panels are tilted at some specified angle. Also, to give mechanical strength the surface of the system is made up of wooden. To achieve more efficient output power we put a vertical panel.

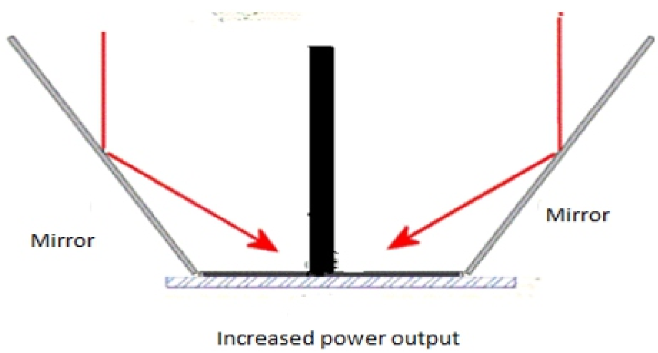


Figure 1: Actual concept (mechanical setup)

Simulation methods and tools

$$Air\ Mass = \frac{1}{\cos(\alpha_{sun})+0.50572(96.07995-\alpha_{sun})} \quad (1)$$

Where,

α_{sun} = sun zenith angle (=90°- sun elevation angle)

The intensity of the direct component of sunlight throughout each day (I_{direct}) can be determined as a function of air mass by Equation (1)

$$I_{direct} = 1.353 \times 0.7^{AM^{0.676}} \quad (2)$$

The theoretical irradiance calculation includes the 10 % diffuse radiation of the direct component. Thus on a clear day, the global irradiance (I_{global}) on a module perpendicular to the sun's rays is determined by Equation (2)

$$I_{global}=1.1\times I_{direct} \quad (3)$$

PV module at an arbitrary tilt and orientation, Equation (4) provides the raw incident panel intensity (S_{panel})

$$S_{panel}=I_{global}\,[\cos(\theta_{sun})\sin(\theta_{panel})\ \cos(\varnothing_{panel}-\varnothing_{sun})+\sin(\theta_{sun})\cos(\theta_{panel}) \quad (4)$$

Where,

θ_{sun} = sun elevation angle

$\varnothing_{sun}$ = sun azimuth angle

θ_{panel} = panel tilt angle

$\varnothing_{panel}$ = azimuth angle that the panel faces.

A PV panel lying flat on the ground has θ_{panel} =0° and a vertical panel has a θ_{panel} =90°. A similar concept was used to represent the incident solar mirror intensity (S_{mirror}), reflected onto the PV panel shown in Equation (5)

$$S_{mirror}=I_{global}\,[\cos(\theta_{sun})\sin(\theta_{mirror})\cos(\varnothing_{mirror}-\varnothing_{sun})+\sin(\theta_{sun})\cos(\theta_{mirror})]\,R_{mirror} \quad (5)$$

Where,

θ_{mirror} = mirror tilt angle

∅_mirror = azimuth angle that the mirror faces

R_{mirror} = reflectivity of the solar mirror developed by Replex Plastics.

The mirror throw distance can be obtained by simply calculating the geometry of the system as shown in equation (6)

$$Dist_{mirror} = \frac{L_{mirror}\sin(\theta_{sun}-\theta_{mirror})}{\sin(\theta_{panel}-\theta_{sun}+2\theta_{mirror})} \quad (6)$$

The shadow distance can also be obtained to represent the region, which was by reflected ray due to mirror blocking as shown in equation (7)

$$Dist_{shadow} = \frac{L_{mirror}\sin(\theta_{mirror}-\theta_{sun})}{\sin(\theta_{panel}+\theta_{sun})} \quad (7)$$

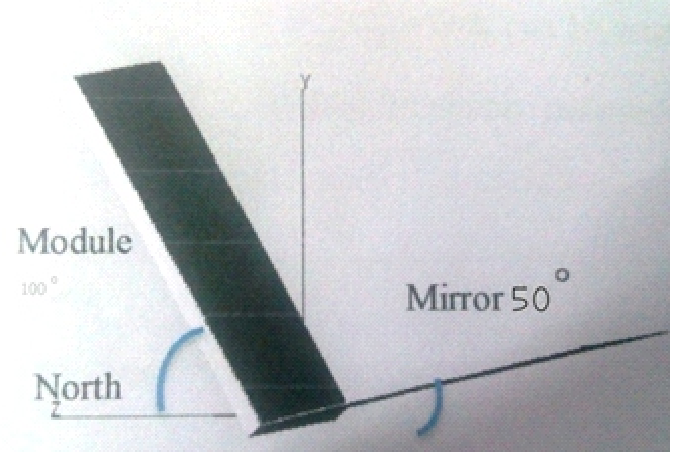


Fig 2: Angle setup

Another application will be water heater. Aluminum tank are used for water heating purpose. As shown in fig. 3

Fig 3: mechanical setup

Aluminum will used because it's most important property is thermal expansion. The coefficient of thermal expansion is non-linear over the range from minus 200 to plus 6000C but for practical purposes is assumed to be constant between the temperature range from 20 to 1000C. The coefficient of thermal expansion of alloys is affected by the nature of their constituents: the presence of silicon and copper reduces expansion while magnesium increases it. For the common commercially used wrought alloys, the coefficient of expansion varies from 23.5 x 10-6 /K for 4.6% Cu aluminium alloy to 24.5 x 10-6 /K for 4.5 % Mg aluminium alloy, i.e. twice that of steel.

Some high silicon cast alloys specially developed for the manufacture of internal combustion engine pistons and cylinder heads have a coefficient of expansion as low as 16 x 10-6/K while in some aluminum metal matrix composites the coefficient is reduced to 12.2 x 10-6/K by the addition of 38% silicon carbide. Metal matrix composites are a comparatively recent development, and shows how the volume of silicon carbide can be changed to tailor the coefficient of expansion to match the common engineering metals.

The differential coefficient of expansion should be taken into consideration when aluminum is used in conjunction with other materials, e.g. large aluminium/steel structures. However, the stresses induced are moderated by aluminium's low elastic modulus which is one third that of steel. Only where dimensions are really large, and the structural members slender (laterally unstable) does the connection to steel pose a differential expansion problem. This would apply with curtain walls for high rise buildings and parapets for bridges where long slender aluminium extrusions are set on steel frameworks. In these cases slip joints, plastic caulking and other stress-relieving devices are usually needed . In cases where the structure is stiff and unlikely to buckle such as an aluminum superstructure on a steel hulled ship all joints are now made rigid and the differential expansion is accepted as a compressive or tensile stress . Another form of dimensional change, which does not directly affect the user of aluminium but is important in the production of castings, is the contraction of the metal on solidification; this is dependent upon alloy and is between 1 and 2% (comparative figures for iron, steel and brass are 1%, 2%, and 1.5%, respectively).

Result

Sr. no	Solar pane SolSolar panel output voltage vpanel output Sol output	
	Without mirror(vtg)	With mirror(vtg)
1	4.1	4.8
2	6.2	6.9
3	6.5	8.2
4	8.1	10
5	8.5	10.5
6	9.1	12
7	9.6	10.1
8	9.7	10.4
9	5.3	9.2
10	5	8.2

Calculation -

Rating of two solar panel = 8.9v 5watt

Actual maxi capacity of output = 6.5volt
= 6.5×2
=13volt

Mean of without mirror reflection vtg = 63.9volt

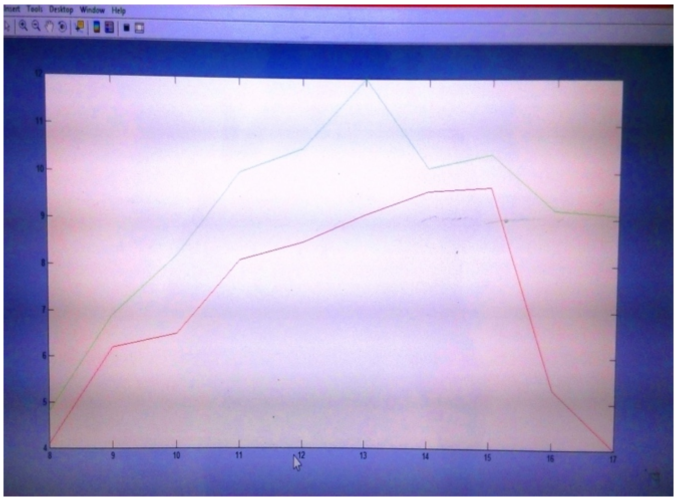
Mean of with mirror reflection vtg = 91.3volt

$$\text{Efficiency of without mirror} = \frac{63.9}{130} \times 100 = 49.15\%$$

$$\text{Efficiency of with mirror} = \frac{91.3}{130} \times 100 = 70.23\%$$

Difference will be = 21%

Graph



Conclusion

The developed new cost effective mirror reflecting type PV solar energy concentrator system has several advantages in comparison with well known systems. It is mostly protected from environmental influences (wind, dust, rain, hail) and has the simple structure. Due to the simplified structure of concentrating optics, the standard off-the-shelf technologies enable low-cost manufacturing. The developed optimization method and computer program allows to design the cost effective flat mirror reflecting linear focus PV solar energy concentrating systems.

Photovoltaic electricity has the potential to serve as a competitive and efficient energy source in the future. However, the prime cost of this technology is still higher than nuclear, thermal and wind power. One simple and effective way to drive down the cost of PV electricity is to combine reflectors with PV panels in order to harvest more light from the modules. The optical analysis and experimental current and voltage data both show that the with mirror system has higher power output compared to without mirror system.

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